SECONDARY
ALUMINUM OPERATIONS
AP-42 Section ~~7.8~~ 12.8
Reference Number
~~#8~~ 6

# AIR POLLUTION ENGINEERING MANUAL

## SECOND EDITION

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Table 82. EFFICIENCIES OF WET SCRUBBER CONTROL DEVICES SERVING BRASS-MELTING FURNACES

| Type of scrubber | Water rate, gpm | Flue gas volume, scfm | Particulate matter, gr/scf | | Total dust, lb/hr | | Efficiency, % |
|---|---|---|---|---|---|---|---|
| | | | In | Out | In | Out | |
| Venturi with wet cyclone | 7.6 | 860 | 2.71 | 0.704 | 19.95 | 7.04 | 65 |
| Dynamic wet | 20.0 | 770 | 0.905 | 0.367 | 5.97 | 3.00 | 50 |
| Dynamic wet | 50.0 | 1,870 | 1.76 | 0.598 | 28.2 | 13.2 | 53 |

Collectors depending upon centrifugal principles alone are not adapted to brass furnace dust collection because of the low efficiency of these devices on submicron-sized particulate matter. One Los Angeles foundry operated a wet cyclone gas conditioner venting to a wet entrainment separator for recovering partially agglomerated zinc oxide fume. The concentration of particulate matter was relatively small, since tilting crucible furnaces with slag covers were used, and the device was able to reduce the weight of the dust and fumes emitted below the legal limits, but the number of unagglomerated submicron-sized particles escaping collection was sufficient to cause periodic opacity violations. Consequently, this unit has been replaced by a baghouse.

## SECONDARY ALUMINUM-MELTING PROCESSES

### TYPES OF PROCESS

Secondary aluminum melting is essentially the process of remelting aluminum, but the term encompasses the following additional practices:

1. Fluxing. This term is applied to any process in which materials are added to the melt to aid in removal of gases, oxides, or other impurities, but do not remain in the final product.
2. Alloying. This term is applied to any process in which materials are added to give desired properties to the product and become part of the final product.
3. Degassing. This includes any process used to reduce or eliminate dissolved gases.
4. "Demagging." This includes any process used to reduce the magnesium content of the alloy.

These terms are often used vaguely and overlap to a great extent. For example, degassing and demagging are usually accomplished by means of fluxes. The use of zinc chloride and zinc fluoride fluxes increases the zinc content of aluminum alloys.

Aluminum for secondary melting comes from three main sources:

1. Aluminum pigs. These may be primary metal but may also be secondary aluminum produced by a large secondary smelter to meet standard alloy specifications.
2. Foundry returns. These include gates, risers, runners, sprues, and rejected castings. In foundries producing sand mold castings, foundry returns may amount to 40 to 60 percent of the metal poured.
3. Scrap. This category includes aluminum contaminated with oil, grease, paint, rubber, plastics,and other metals such as iron, magnesium, zinc, and brass.

The melting of clean aluminum pigs and foundry returns without the use of fluxes does not result in the discharge of significant quantities of air contaminants. The melting of aluminum scrap, however, frequently requires air pollution control equipment to prevent the discharge of excessive air contaminants.

#### Crucible Furnaces

For melting small quantities of aluminum, up to 1,000 pounds, crucible or pot-type furnaces are used extensively. Almost all crucibles are made of silicon carbide or similar refractory material. Small crucibles are lifted out of the furnace and used as ladles to pour into molds. The larger crucibles are usually used with tilting-type furnaces. For die casting, molten metal is ladled out with a small hand ladle or it can be fed automatically to the die-casting machine.

### Reverberatory Furnaces

The reverberatory furnace is commonly used for medium- and large-capacity heats. Small reverberatory furnaces up to approximately 3,000 pounds' capacity may be of the tilting type. Sometimes a double-hearth construction is employed in furnaces of 1,000 to 3,000 pounds' holding capacity. This permits melting to take place in one hearth, the second hearth serving only to hold the molten metal at the appropriate temperature. Advocates of this design stress that it reduces or eliminates the tendency of the metal to absorb gas. The contention is that porosity results from hydrogen gas, which is liberated from moisture trapped below the surface of molten aluminum. The use of a double hearth permits moisture to be driven off before the metal melts and runs to the holding hearth. Sometimes the melting hearth is also used as a sweat furnace to separate the aluminum from contaminants such as brass and steel. The use of double-hearth furnaces for the larger capacity heats is not common.

A charging well is frequently used on aluminum reverberatory furnaces. Figure 197 shows a 20-ton reverberatory furnace with a charging well. The well permits chips and other small aluminum scrap to be introduced and immersed below the liquid level. Chips and small scrap have an unusually high surface area-to-volume relationship, and oxidation must be minimized. Large quantities of flux are also added and stirred in to dissolve the oxide coating and aid in the removal of dirt and other impurities. The flux causes the oxides and other impurities to rise to the surface in the form of a dross that can be skimmed off easily.

Reverberatory furnaces of 20- to 50-ton holding capacity are common. Usually one heat is produced in a 24-hour period; however, the time per heat in different shops varies from 4 hours to as much as 72 hours. This type of furnace is commonly used to melt a variety of scrap. The materials charged, method of charging, size and design of the furnace, heat input, and fluxing, refining, and alloying procedures all have some influence on the time required to complete a heat. After the charge is completely melted, alloying ingredients are added to adjust the composition to required specifications. Large quantities of fluxes are added when scrap of small size and low grade is melted. The flux in some cases may amount to as much as 30 percent of the weight of scrap charged.

### Fuel-Fired Furnaces

Both gas- and oil-fired furnaces are common, though gas-fired furnaces are usually preferred. Frequently, combination burners are used so that gas may be burned when available, with oil substituted during periods of gas curtailment.

Fuel-fired furnaces used for aluminum melting are extremely inefficient. Approximately 50 percent of the gross heating value in the fuel is unavailable in the products of combustion. Radiation and convection losses are high since little or no insulation is used. Many small crucible furnaces probably do not achieve more than 5 percent overall efficiency and some may not exceed 2 to 3 percent (Anderson, 1925). At the other extreme a properly designed and operated furnace may be able to use as much as 20 percent of the gross heat in the fuel. Most furnaces can be assumed to operate with efficiencies of 5 to 15 percent. This may become an important factor when air pollution control equipment must be provided to handle the products of combustion. Fortunately, this is seldom necessary. Controls, if provided, are usually required only during the degassing or demagging operations when the burners are off. Another possibility is to add fluxes and scrap only to a charging well that is vented to control equipment.

### Electrically Heated Furnaces

Electric induction furnaces are becoming increasingly common for both melting and holding aluminum in spite of higher installation and operating costs. Some of the advantages they offer over other furnaces are higher efficiency, closer temperature control, no contaminants from products of combustion, less oxidation, and improved homogeneity of metal. Electric resistance heating is sometimes used for holding but rarely for melting furnaces. Most electric furnaces for aluminum melting are relatively small though some holding furnaces have capacities up to about 15 tons.

### Charging Practices

Small crucible furnaces are usually charged by hand with pigs and foundry returns. Many reverberatory furnaces are also charged with the same type of materials, but mechanical means are used because of the larger quantity of materials involved.

When chips and light scrap are melted, it is a common practice to melt some heavier scrap or pigs first to form a molten "heel." The light scrap is then added and immediately immersed below the surface of the molten metal so that further oxidation is prevented. The heel may consist of 5,000 to 20,000 pounds, depending upon the size of the furnace.

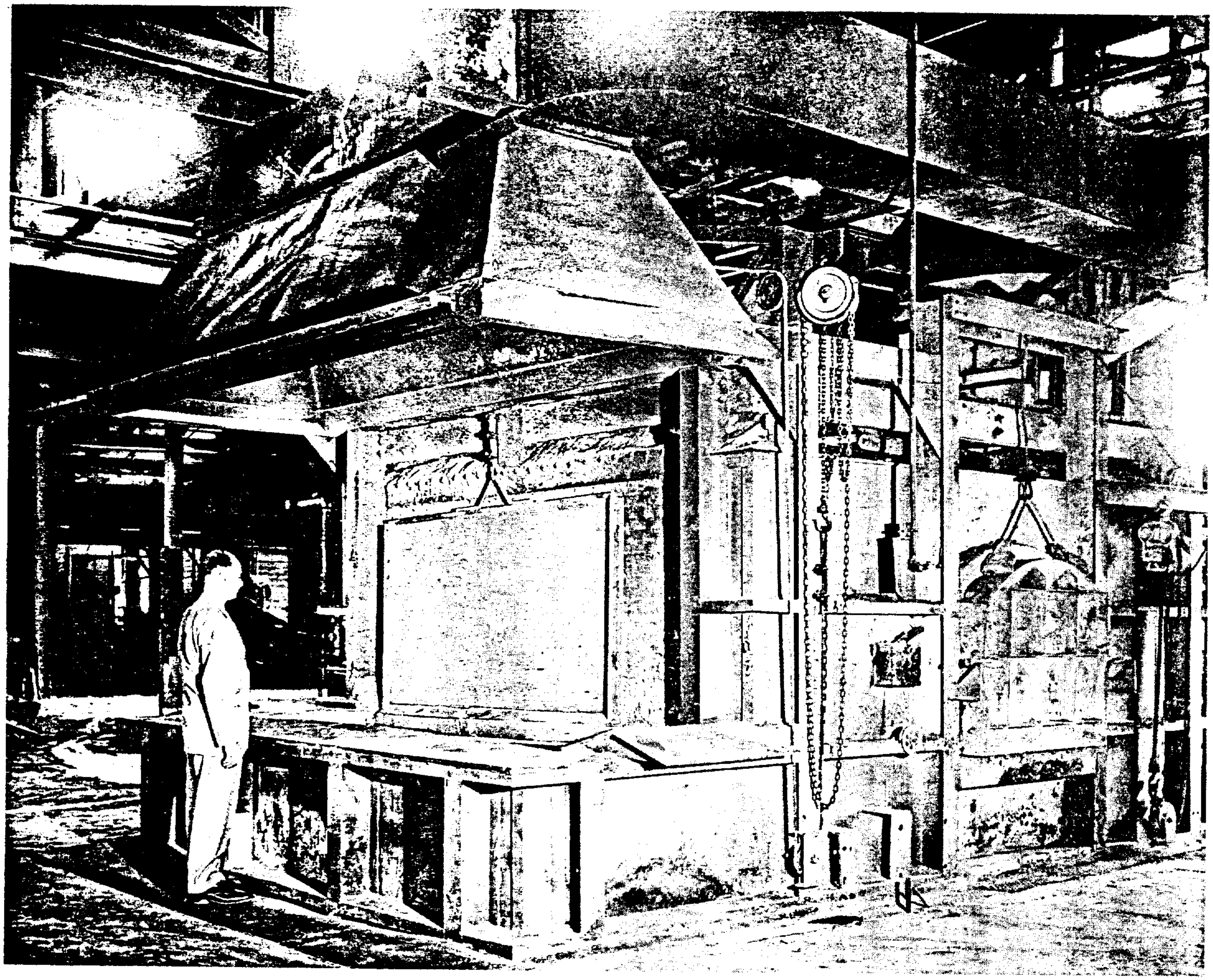

Figure 197. A 20-ton aluminum-melting reverberatory furnace with charging well hood (Aaron, Ferrer & Sons, Inc., Los Angeles, Calif.).

## Pouring Practices

Tilting-type crucible furnaces are used when the crucible is too large to be handled easily. These furnaces are poured into smaller capacity ladles for transfer to the molds. Larger reverberatory furnaces are either tapped from a tap hole or siphoned into a ladle. Ladles vary up to 3 or 4 tons capacity in some cases. Sometimes the ladles are equipped with covers with electric resistance heaters to prevent loss of temperature when the ladle is not to be poured immediately or when the pouring requires too long a time. Pouring molten aluminum does not usually result in the discharge of air contaminants in significant quantities.

## Fluxing

The objectives of fluxing generally fall into four main categories:

1. Cover fluxes. These fluxes are used to cover the surface of the metal to prevent further oxidation and are usually liquid at the melting point of aluminum. Some of these are also effective in preventing gas absorption.

2. Solvent fluxes. These fluxes generally cause the impurities and oxides to float on top of the melt in the form of a dross that can be skimmed off easily.

3. Degassing fluxes. These fluxes are used to purge the melt of dissolved gases. The dissolved gas is assumed to be hydrogen, but other gases are also highly soluble in aluminum. The solubility of gases in molten aluminum increases with temperature. The gases most soluble in molten aluminum, in decreasing order of solubility, are hydrogen, methane, carbon dioxide, sulfur dioxide, oxygen, air, and carbon monoxide. The solubility of hydrogen is 6 or 7 times as great as that of methane and over 10 times that of carbon dioxide. Elimination of hydrogen gas in aluminum is a major problem.

4. Magnesium-reducing fluxes. These fluxes are used to reduce the magnesium content of the alloy (known as demagging). During World War II it became necessary to recover large quantities of aluminum scrap, much of which had a magnesium content too high for the intended use. It was found that the magnesium could be selectively removed by the use of appropriate fluxes.

The quantity and type of fluxing depend upon the the type of furnace, the materials being melted, and the specifications of the final product. A few operators melting only pigs and returns find fluxing unnecessary. At the other extreme are large secondary smelters that process very low-grade scrap and sometimes use fluxes amounting to as much as one-third of the weight of the aluminum scrap charged. About 10 percent by weight is an average figure for the amount of flux used for medium- to low-grade scrap.

Fluxes for degassing or demagging may be either solids or gases. The gaseous types are usually preferred because they are easier to use, and the rate of application is simpler to control. Some of these, for example chlorine, may be used for either degassing or demagging, depending upon the metal temperature. In general, any flux that is effective in removing magnesium also removes gas inclusions.

### Cover fluxes

Cover fluxes are used to protect the metal from contact with air and thereby prevent oxidation. Most of these fluxes use sodium chloride as one of the ingredients (Anderson, 1931). Various proportions of sodium chloride are frequently used with calcium chloride and calcium fluoride. Sometimes cryolite or cryolite with aluminum fluoride is added to dissolve oxides. Borax has also been used alone and in combination with sodium chloride.

### Solvent fluxes

Solvent fluxes usually form a gas or vapor at the temperature of the melt. Their action is largely physical. The resulting agitation causes the oxides and dirt to rise to the top of the molten metal where they can be skimmed off. Included in this group are aluminum chloride, ammonium chloride, and zinc chloride. Zinc chloride increases the zinc content of the alloy probably according to the equation

$$3\ Z_nCl_2 + 2\ Al \rightarrow 3\ Z_n + 2\ AlCl_3 \qquad (100)$$

Aluminum chloride, which is formed in this reaction, is a vapor at temperatures above 352°F. It bubbles out of the melt, forming a dense white fume as it condenses in the atmosphere.

So-called chemical fluxes are solvents for aluminum oxide. Cryolite, other fluorides, or borax is used for this purpose. Part of the action of the fluorides is thought to be due to the liberation of fluorine, which attacks silicates and dirt. Some chlorides are also used extensively, but their action is not understood.

### Degassing fluxes

There are many methods of removing dissolved gas from molten aluminum, some of which do not require the addition of a flux. Among the nonflux methods are the use of vibration, high vacuum, and solidification with remelting. None is as effective as the use of an active agent such as chlorine gas. Helium, argon, and nitrogen gases have also been used successfully. Solid materials that have been used include many metallic chlorides. Some think that their action is physical rather than chemical and that one gas is as good as another. For this reason, nitrogen has been used extensively. Nitrogen is not toxic, and virtually no visible air contaminants are released when it is used. In addition, it does not coarsen the grain or remove sodium or magnesium from the melt. The main objection to the use of nitrogen is that commercial nitrogen is usually contaminated with oxygen and water vapor (Eastwood, 1946).

### Magnesium-reducing fluxes

The use of fluxes to reduce the magnesium content of aluminum alloys is a relatively new procedure. Certain fluxes have long been known to tend to reduce the percent of magnesium in the alloy, but this process did not become commonplace until the advent of World War II. Several fluxes may be used for this purpose. Aluminum fluoride and chlorine gas are perhaps the most commonly used. The temperature of the melt must be significantly greater in demagging than in degassing, usually between 1,400° and 1,500°F.

As much as 1 ton of aluminum fluoride is commonly used in reverberatory furnaces of 40- to 50-ton capacity. The aluminum fluoride is usually added to the molten metal with smaller quantities of other fluxes such as sodium chloride, potassium chloride, and cryolite, and the entire melt is stirred vigorously. Magnesium fluoride is formed, which can then be skimmed off. Large quantities of air contaminants are discharged from this process.

Magnesium reduction with chlorine

Chlorine gas used for demagging is easier to regulate than fluxes used for that purpose. Extra precautions must be taken because of the high toxicity of this material. The chlorine is sent under pressure through carbon tubes or lances to the bottom of the melt and permitted to bubble up through the molten aluminum. Figure 198 (left) shows a ladle of aluminum before the lances are lowered into the metal; Figure 198 (right) shows the hood in position.

Recently, aluminum reverberatory furnaces have been provided with chlorination chambers. A typical chamber is approximately 4 feet wide and 10 feet long, and is located alongside the furnace. An archway beneath the molten metal level in the common wall between the furnace and the chamber permits the flow of metal between the furnace and the chamber. Chlorine under pressure is fed through carbon lances to the bottom of the melt in the chlorination chamber. Use of this chamber permits chlorination during the latter part of the melting cycle and has the added advantage of isolating the contaminant gases and entrained emissions, formed by the demagging process, from the combustion products of the furnace.

## THE AIR POLLUTION PROBLEM

Frequently, a large part of the material charged to a reverberatory furnace is low-grade scrap and chips. Paint, dirt, oil, grease, and other contaminants from this scrap cause large quantities of smoke and fumes to be discharged. Even if the scrap is clean, large surface-to-volume ratios require the use of more fluxes, which can cause serious air pollution problems.

In a study of the extent of visible emissions discharged from degassing aluminum with chlorine

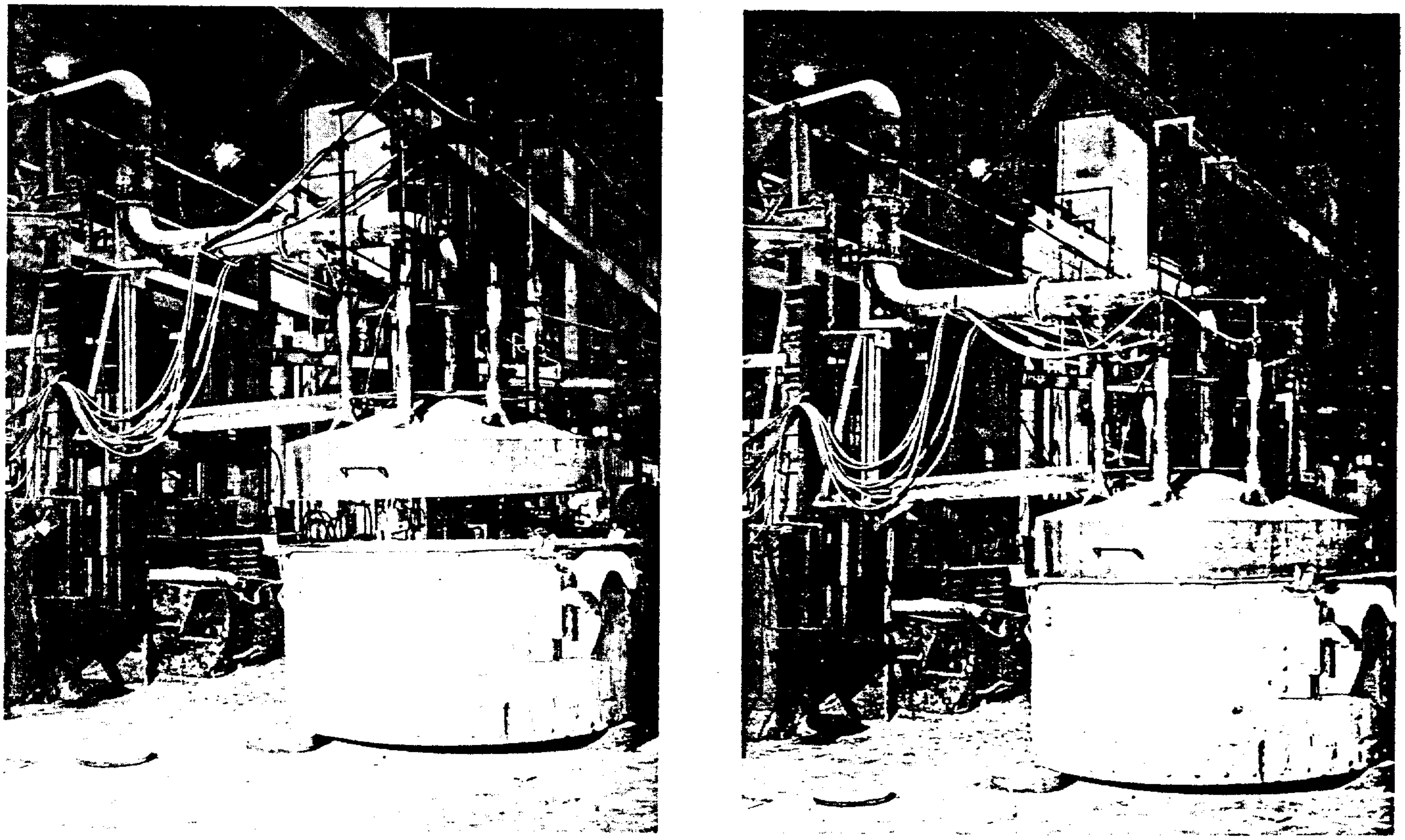

Figure 198. Ladle of molten aluminum with (left) lances in the raised position, and (right) hood in place and lances lowered into aluminum.

gas, the major parameters were found to be metal temperature, chlorine flow rate, and magnesium content of the alloy. Other factors affecting the emissions to a lesser degree are the depth at which the chlorine is released and the thickness and composition of the dross on the metal surface. Other factors remaining constant, the opacity of the emissions at any time is an inverse function of the percent magnesium in the metal at that time.

When the magnesium content is reduced, either by combining with chlorine to form magnesium chloride ($MgCl_2$) or by using an alloy containing less magnesium, a greater fraction of the chlorine combines with the aluminum to form aluminum chloride ($AlCl_3$). The magnesium chloride melts at about 1,312°F, so that it is a liquid or solid at normal temperatures for this operation (about 1,300° to 1,350°F) and thus does not contribute significantly to the emissions. A very small amount may sometimes be released into the atmosphere as a result of mechanical entrainment. The aluminum chloride, on the other hand, sublimes at about 352°F, so that it is a vapor at the temperature of molten aluminum. As the vapors cool in the atmosphere, submicron fumes are formed, which have very great opacity in proportion to the weight of material involved.

Chlorine has a much greater affinity for magnesium than it has for aluminum. This is shown by the fact that alloys containing more than about 0.5 percent magnesium (and 90 to 97 percent aluminum) usually produce only a moderate quantity of fume in degassing with chlorine, while alloys with more than about 0.75 percent magnesium do not usually produce a significant quantity of fume.

In alloys with greater magnesium content, not only is less aluminum chloride formed, but also a thick layer of dross (largely magnesium chloride) is built up on the surface, which further suppresses the emission of fumes. Aluminum chloride also reacts with magnesium to form magnesium chloride and aluminum. The dross increases the opportunities for this latter reaction.

When chlorine is used for demagging, it is added so rapidly that large quantities of both aluminum chloride and magnesium chloride are formed, the molten bath is vigorously agitated, and not all of the chlorine reacts with the metals. As a result, a large quantity of aluminum chloride is discharged along with chlorine gas and some entrained magnesium chloride. The aluminum chloride is extremely hygroscopic and absorbs moisture from the air, with which it reacts to form hydrogen chloride. These air contaminants are toxic, corrosive, and irritating.

### Particle Size of Fumes From Fluxing

One study (McCabe, 1952) found that the major constituent in the fume from salt-cryolite fluxing in a furnace was sodium chloride with considerable smaller quantities of compounds of aluminum and magnesium. Electron photomicrographs of thermal precipitator samples indicated that the particles of fume were all under 2 microns, most of them being 0.1 micron. The fumes were somewhat corrosive when dry and, when collected wet, formed a highly corrosive sludge that tended to set up and harden if allowed to stand for any appreciable time. Another study made of the fume from chlorinating aluminum to degas revealed that 100 percent of the fume was smaller than 2 microns and 90 to 95 percent smaller than 1 micron. Mean particle size appeared under a microscope to be about 0.7 micron.

## HOODING AND VENTILATION REQUIREMENTS

When no charging well is provided, or when fluxing is done inside the furnace, or when dirty scrap is charged directly into the furnace, then venting the furnace may be necessary. In some cases, the products of combustion must be vented to the air pollution control equipment. The volume to be vented to the collector, and the determination of temperature may be found similarly to metallurgical furnace calculation procedures described elsewhere in this manual.

A canopy hood (as previously shown in Figure 197) is usually used for capturing the emissions from the charging well of an aluminum reverberatory furnace. Calculation of the quantity of air required can be accomplished as shown in the following example.

Example 29

Given:

Metal surface, 2 ft 3 in. x 11 ft 3 in.
Temperature of molten metal, 1,350°F.
Hood opening dimensions, 3 ft 9 in. x 13 ft 9 in.
Height of hood face above metal surface, 2 ft 6 in.
Ambient air temperature, 80°F.

Problem:

Determine the volume of air that must be vented from a low-canopy hood over the charging well of an aluminum-melting reverberatory furnace to ensure complete capture of the air contaminants.

Solution:

As discussed in Chapter 3, the following equation gives the total ventilation rate for low-canopy hoods:

$$q = 5.4\,(A)(m)^{1/3}\ (\Delta t)^{5/12}$$

where

$q$ = total ventilation rate required, cfm

$A$ = area of the hood face, ft$^2$

$m$ = the width of the hot metal surface at the charging well, ft

$\Delta t$ = the difference in temperature between the hot surface and the ambient air, °F.

$$q = (5.4)(3.75)(13.75)(2.25)^{1/3}\ (1{,}350-80)^{5/12}$$

$$= 7{,}170 \text{ cfm}$$

Problem note: The volume calculated here is the minimum ventilation required just to accommodate the rising column of air due to the thermal drive. An additional allowance must be made to take care of drafts. If volatile fluxes are used, the volume of fumes generated must also be accommodated. In most cases an allowance of about 25 percent additional volume is adequate to ensure complete pickup. The exhaust system should therefore be designed to vent about 9,000 cfm.

Although the gases vented from the charging well are hot, sufficient air is drawn into the hood to preclude any danger that the hot gas will damage the exhaust system. The temperature of the mixed gas stream is calculated in example 30.

Example 30

Given:

The furnace with charging well and canopy hood venting 9,000 cfm as shown in Example 29.

Problem:

Determine the temperature of the air entering the hood.

Solution:

1. Determine the heat transferred from the hot metal surface to the air by natural convection:

From Chapter 3, $H' = \dfrac{h_c\, A_s\, \Delta t}{60}$

where

$H'$ = heat transferred from hot metal surface to the air by natural convection, Btu/min

$h_c$ = coefficient of heat transfer from horizontal plates by natural convection, Btu/hr/ft$^2$/°F

$A_s$ = area of hot metal surface, ft$^2$

$\Delta t$ = temperature difference between hot metal surface and ambient air, °F.

By using $h_c = 0.38\,(\Delta t)^{0.25}$ and substituting this quantity into the equation,

$$H' = \frac{0.38\,(A_s)(\Delta t)^{1.25}}{60}$$

$$H' = \frac{(0.38)(2.25)(11.25)(1{,}350-80)^{1.25}}{60}$$

$$= 1{,}210 \text{ Btu/min}$$

2. Solve for temperature of the air entering the hood (assume specific volume of air = 13.8 ft$^3$/lb):

$$q = W\, c_p\, \Delta t$$

where $c_p$ = specific heat of air at constant pressure.

$$\Delta t = \frac{(1{,}210)(13.8)}{(9{,}000)(0.24)} = 7.7\text{°F}$$

Temperature of air entering the hood = 80 + 7.7 = 87.7°F.

The actual temperature of the air entering the hood will be slightly higher than the value calculated here, owing to radiation from the molten metal surface, and radiation and convection from the hood and the furnace. In some cases, when the burners are operated at maximum capacity, there may be a positive pressure in the furnace. If the design of the furnace permits some of the products of combustion to be vented into the hood, the actual temperature may be substantially higher than shown here. This situation would also require venting a greater volume to ensure capturing the emissions.

## AIR POLLUTION CONTROL EQUIPMENT

The emissions from aluminum fluxing may consist of hydrogen fluoride, hydrogen chloride, and chlorine in a gaseous state, and aluminum chloride, magnesium chloride, aluminum fluoride, magnesium fluoride, aluminum oxide, magnesium oxide, zinc chloride, zinc oxide, calcium fluoride, calcium chloride, and sodium chloride in the solid state. Not all will be present at one time, and many other, minor contaminants may be emitted in a specific case. Because of the widely divergent properties of these various air contaminants, the problem of control is complicated.

Some type of scrubber is required to remove the soluble gaseous fraction of the effluent, and either a baghouse or an electrical precipitator is needed to control the solids. In order to obtain adequate collection efficiency, the use of high-efficiency scrubbers, with a caustic solution as the scrubbing medium, has been found necessary. This is illustrated in Table 83, which shows typical test data on collection efficiency for both ordinary and high-efficiency scrubbers.

Table 83. SCRUBBER COLLECTION EFFICIENCY FOR EMISSIONS FROM CHLORINATING ALUMINUM

| | Scrubber collection efficiencies, %[a] | | | |
|---|---|---|---|---|
| | Slot scrubber | | Packed-column scrubber | |
| Contaminants | Water | 10% caustic solution | Water | 10% caustic solution |
| HCL | 90 to 95 | 95 to 99 | 95 to 98 | 99 to 100 |
| $CL_2$ | 30 to 50 | 50 to 60 | 75 to 85 | 90 to 95 |
| Particulates | 30 to 50 | 50 to 60 | 70 to 80 | 80 to 90 |

[a] Collection efficiency depends mainly upon scrubbing ratio (gal per 1,000 $ft^3$), velocity of gas in scrubber, and contact time and to a lesser extent on other aspects of the design. These values are typical efficiencies obtained by actual tests but do not reflect the entire range of results.

Table 84 summarizes the results of a series of 200 tests made of control efficiencies of nine devices by a major producer of aluminum (Jenny, 1951). These results represent the average range of efficiencies for a number of tests but are not necessarily the maximum or minimum values obtained. In spite of the high efficiencies obtained with some of these devices, reducing the emissions sufficiently to eliminate a visible plume was very difficult. For the dry ultrasonic unit, the opacity of the emissions exceeded 40 percent when the outlet grain loading was greater than 0.25 grain per cubic foot. The efficiency of this unit varied widely with the inlet grain loading and retention time, the efficiency increasing with increasing values of either or both of these variables. Other tests by the same company on collectors of a wet type revealed that the opacity exceeded 40 percent periodically, even when the average grain loading at the vent was as low as 0.002 grain per cubic foot.

Table 84. AVERAGE COLLECTION EFFICIENCY OBTAINED BY VARIOUS DEVICES ON EMISSIONS FROM CHLORINATING ALUMINUM (Jenny, 1951)

| Type of device | Efficiency, % |
|---|---|
| Horizontal multipass wet cyclone | 65 to 75 |
| Single-pass wet dynamic collector | 70 to 80 |
| Packed-column water scrubber with limestone packing | 75 to 85 |
| Ultrasonic agglomerator followed by a multitube dry cyclone | 85 to 98 |
| Electrical precipitator | 90 to 99 |

Figures 198, 199, and 200 show parts of a single installation of air pollution control equipment for the control of emissions from chlorinating aluminum. One of the three stations where chlorinating is performed is shown in Figure 198. Note that the hooding closely encloses the source so that a minimum volume of air is required to attain 100 percent pickup of air contaminants. The fumes are scrubbed in the packed-column scrubbers shown in Figure 199. This system was designed to use two of the three scrubbers in parallel, with the third as a standby. The scrubbing medium is a 10 percent caustic solution. After the scrubbing, the effluent is vented to a five-compartment baghouse with a fully automatic shaking mechanism to remove residual particulate matter. The baghouse contains a total of 300 orlon bags with a net filtering area of 12,000 square feet. In addition to the fumes from chlorine fluxing, which are vented through the scrubbers, two aluminum dross-processing barrels (Figure 200) are vented directly to the baghouse. The total volume handled by the baghouse is about 30,000 cfm, of which

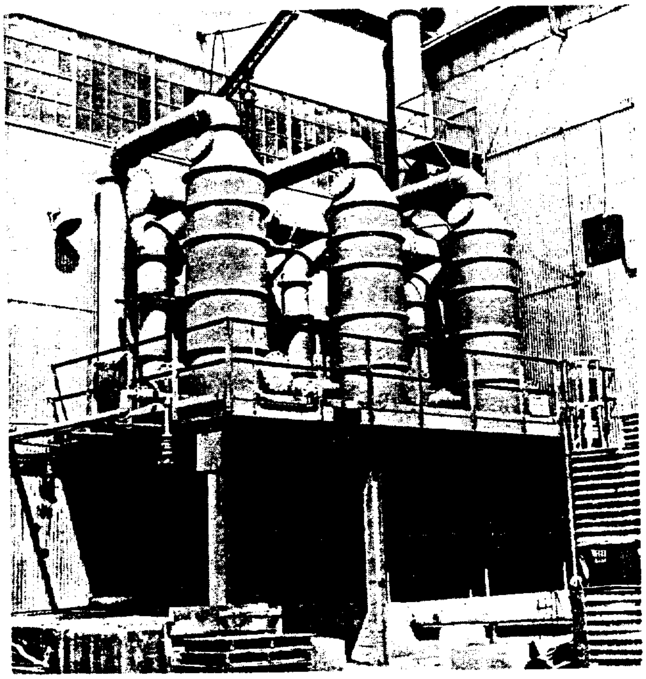

Figure 199. High-efficiency packed-column water scrubbers used with a baghouse for control of emissions from chlorine fluxing and dross processing.

approximately 6,000 cfm is from the three chlorine fluxing stations and the balance from the two dross barrel hoods. The beneficial effect of the bag precoating provided by the aluminum oxide dust vented from the dross-processing barrels permits a much higher filtering velocity than would be advisable if only the fluxing stations were being served by the baghouse.

Tests of the scrubber performance have shown that virtually all the hydrogen chloride and more than 90 percent of the chlorine are removed by the caustic scrubbing solution. Since the efficiency of aluminum chloride removal averages in excess of 80 percent, the loading of hygroscopic and corrosive materials to the baghouse is relatively light. The aluminum oxide dust from the dross barrels acts as a filter cake, which improves the collection efficiency of the aluminum chloride fume while simultaneously reducing or eliminating the difficulties usually associated with collecting hygroscopic materials. All exposed metal parts are coated with polyvinyl chloride or other appropriate protective coatings. The first year of operation indicates that no serious operational or maintenance problems will develop. This installation replaced an electrical precipitator that was found extremely difficult and expensive to maintain because of corrosion.

An electrical precipitator that has been used successfully to control the emissions from fluxing aluminum is illustrated in Figure 201. At present the trend in control equipment for aluminum-fluxing emissions appears to be away from electrical precipitators and toward the scrubber-baghouse combination.

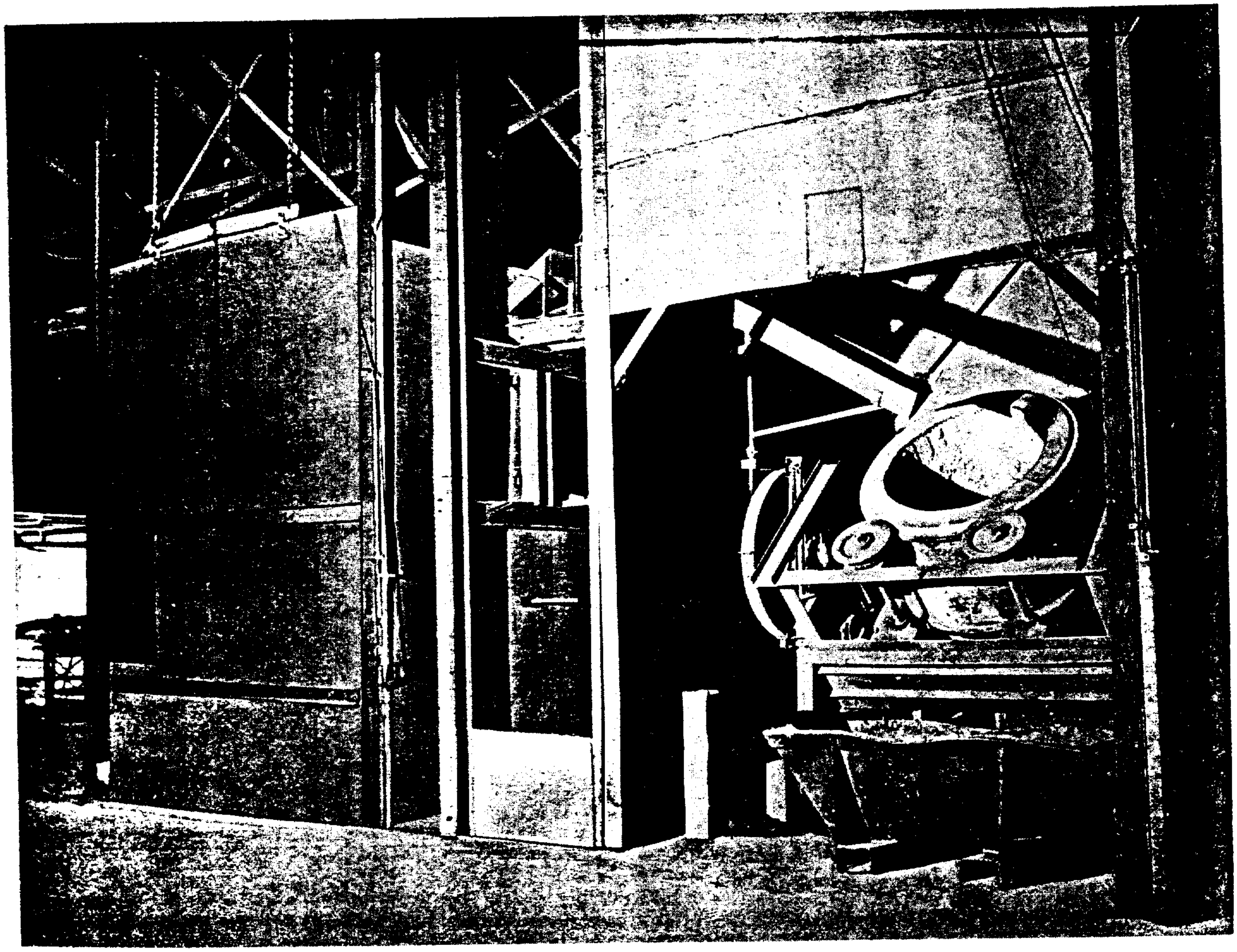

Figure 200. Two aluminum dross-processing stations, one shown with hood door raised.

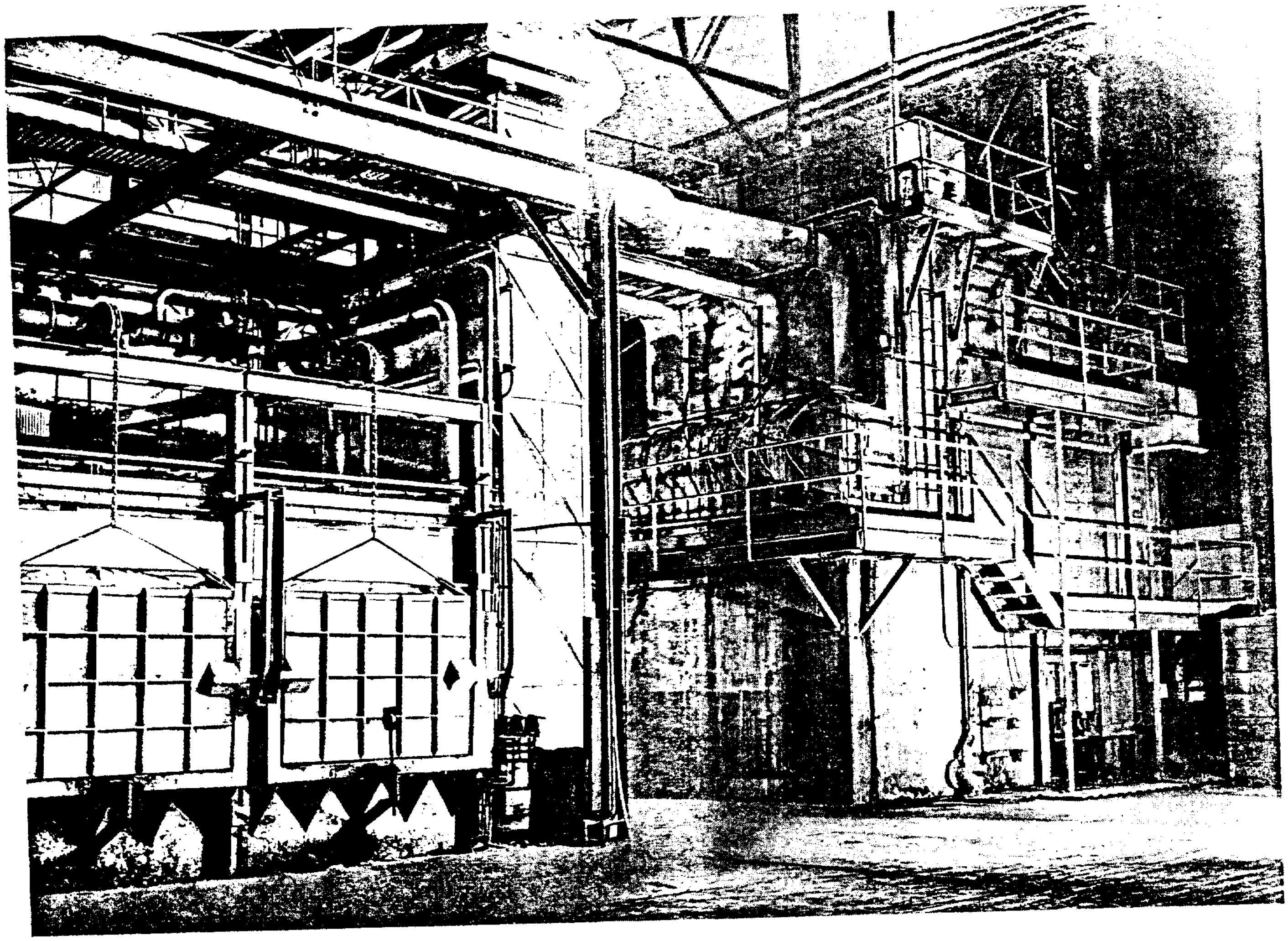

Figure 201. Concrete shell-type electrical precipitator used for controlling emissions from fluoride fluxing aluminum metal. The reverberatory furnace is shown in the left portion of the photograph (Apex Smelting Co., Long Beach, Calif.).

As mentioned earlier in this section, the demagging operation can be done in a separate chlorination chamber. Exhaust volumes required to control the emissions are much lower when a chlorination chamber is used than when demagging is done in the main chamber of the furnace. The chlorination chamber is virtually sealed from the atmosphere, the only exception being the cracks in the refractory. An exhaust system capable of providing 300 to 500 cfm is sufficient to remove all of the HCl and chlorine gas from the chamber and, additionally, to provide a slight negative pressure within it.

The control system consists of (1) a settling chamber, where some agglomeration and settling takes place; (2) a packed-tray-type scrubber utilizing 10 percent caustic solution, where virtually all of the chlorine and nearly all of the HCl is removed, together with the major portion of the remaining particulate matter; and (3) a baghouse, where the remaining particulate is separated from the effluent. Since the particulates are hygroscopic and the gas stream from the scrubber to the baghouse is nearly saturated with water, the effluent must be heated to about 175° F to prevent combustion in the baghouse.

This combination control system has proved successful in controlling demagging emissions; however, maintenance costs are high. All ductwork from the chlorination chamber to the scrubber must be cleaned of settled particulates soon after each chlorination; otherwise, they harden and are very difficult to remove. The packed-tray-type scrubber also should be washed free of all collected particulate after each chlorination. If this is not done, stratification of the effluent and caustic hampers removal of the chlorine and HCl. Then corrosion occurs in the baghouse and on structures near the baghouse.